COMPUTE PROJECT BILL OF MATERIALS (B.O.M)

EAC-B01

BILL OF MATERIALS, B.O.M. OVERVIEW

The purpose of this lesson is to provide you with the knowledge to estimate the material requirements for a vertical construction project.

LEARNING OBJECTIVES TLO

Provided a vertical construction mission,a scientific calculator, a computer, software applications, and references, compute a project bill of materials to account for all Class IV quantities per the

LEARNING OBJECTIVES ELO

- **(1). Provided written project specifications, design**

drawings, a scientific calculator, blank material takeoff sheets,

and references, calculate concrete requirements per the FM

5-428. (1361-SRVY-2003a)

- **(2). Provided written project specifications, design**

drawings, a scientific calculator, blank material takeoff sheets,

and references, calculate masonry requirements per the FM

5-428. (1361-SRVY-2003b)

- **(3). Provided written project specifications, design**

drawings, a scientific calculator, blank material takeoff sheets,

LEARNING OBJECTIVES ELO

- **(4). Provided written project specifications, design**

drawings, a scientific calculator, blank material

takeoff sheets, and references, calculate finish

material requirements per the FM 5-426.

(1361-SRVY-2003d)

- **(5). Provided written project specifications, design**

drawings, a scientific calculator, completed

lumber/plywood consolidations, blank material

estimate sheets, and references, estimate

construction hardware quantities per the FM 5-426.

METHOD & MEDIA

- Lecture
- Demonstration
- Practical Application
  - Computer Slides
  - Dry-erase Board

EVALUATION

- Performance Evaluation Exam

SAFETY / CEASE TRAINING (CT) BRIEF

- Fire
- Tornado
- Safety is Paramount

QUESTIONS

PRINCIPLES OF ESTIMATING

- Estimating is the calculation of the approximate amount of material and/or labor requirements to build a construction project.
- Estimates are prepared from finished working drawings and project specifications.

QUALIFICATIONS:

- Be able to read and scale drawings.
- Posses a good working knowledge of math.
- Be able to visualize the work required.
- Working knowledge of construction methods and materials.
- Knowledge and ability to assemble materials into working units.

2 BASIC CALCULATIONS

- **Measurement:**
  - Descriptions of materials and items of work.
  - Dimensions of items of work, and materials required.
  - Calculating the quantities of materials, and items of work.

- **Pricing:**
  - Arithmetic used to determine the costs of items

?

- Name some of the qualifications an estimator need to have in order to compile accurate estimates.
- What are the two basic calculations involved in construction project estimations?

MATHEMATICAL EQUATIONS

The application of basic mathematical computations is all that is necessary to compile accurate project material and/or labor requirements.

- **Three basic conversions:**
  - **Linear**
  - **Area**
  - **Volume**

LINEAR CONVERSION (INCHES / FEET)

Conversions used to determine such items of work such as: rafter, joist & stud requirements.

- Feet x 12 = inches
  - ***3’ x 12 = 36”***
- Inches / 12 = Decimal feet
  - ***36” ÷ 12 = 3’***
- Fractions:
  - **Numerator / denominator = Decimal parts of an inch.**
    - ***¾”: 3 ÷ 4 = 0.75”***
- Decimals:
  - **Decimal parts of an inch / 12 = Decimal parts of a foot.**
    - ***0.75” ÷ 12 = .0625’***

LINEAR CONVERSION CALCULATION

DEMONSTRATION

AREA CONVERSION (SQUARE FEET)

- Conversion used to determine such items of work such as: plywood, paint, siding & concrete block requirements.
  - Rectangles:
    - Walls: L (ft) x H (ft) = Area (sqft/sf)
    - Floors: L (ft) x W (ft) = Area (sqft/sf)
      - ***10’ x 8’ = 80 sqft***
  - Triangles:
    - $\frac{\text{Base (ft) x H (ft)}}{2}$ = Area (sqft/sf)
      - $\frac{\textbf{10’ x 10}}{2} = \textbf{25sqft}$
  - Trapezoids:
    - H (ft) x ½ the sum of the parallel sides = Area (sqft/sf)
      - ***10’ x ((20 + 40) ÷ 2) = 300 sqft***

AREA CONVERSION CALCULATION

DEMONSTRATION

VOLUME CONVERSION (CUBIC FEET & CUBIC YARDS)

- Conversions used to determine such items as concrete, sand, aggregate & mortar.
  - L (ft) x W (ft) x H (ft) = Volume (cuft/cf)
    - ***10’ x 10’ x 8’ = 800 cuft***
  - Volume (cf) ÷ 27 = Volume (cuyd/cy)
    - ***800 cf ÷ 27 = 29.63 cuyd***
  - Volume (cy) x 27 = Volume (cuft/cf)
    - ***29.63 cy x 27 = 800 cuft***

VOLUME CONVERSION CALCULATION

DEMONSTRATION

PERIMETER RULE

- A progressive calculation to compute areas and volumes.
- Rectangular Shaped:
  - **Footing dimensions**:
    - Length: 32.67’
    - Width: 16.67’
    - Height: 0.67’
    - Depth: 1.33’
  - (Outside length (ft) + Inside width (ft)) x 2 = Total perimeter length (ft)
    - ***(32.67’ + 14.01’) x 2 = 93.36’***
  - Total perimeter length (ft) x H (ft) = Area (sqft/sf)
    - ***93.36’ x 0.67’ = 62.55 sqft***
  - Area (sf) x D (ft) = Volume (cuft/ft)
    - ***62.55 (sf) x 1.33’ = 83.19***

PERIMETER RULE (CONTINUED)

- Irregular Shaped:
  - Pentagon (5 sides)
    - Footing Length (one side): 20.48’
    - Height: 0.67’
    - Depth: 1.33’
    - Total outside perimeter length: 102.4’
    - Total inside perimeter length: 95.75’
  - (Outside Length (ft) + Inside Length (ft)) ÷ 2 = Total continuous perimeter length (ft)
    - ***(102.4’ + 95.75’) ÷ 2 = 99.08’***
  - Total continuous perimeter length (ft) x H (ft) = Area (sqft/sf)
    - ***97.58’ x 0.67’ = 66.38 sqft***
  - Area (sf) x D (ft) = Volume (cuft/cf)

PERIMETER RULE CALCULATION

DEMONSTRATION

STANDARD LUMBER LENGTH CALCULATION

- Used to determine the optimum length of lumber to minimize waste, when cutting specific small items of work.

- Used for:
  - Bridging
  - Blocking
  - Treads & Risers
  - Headers
  - Jack Studs
  - etc…

STANDARD LENGTH CALCULATION (PART 1)

- Length In Place (LIP) Measurement (in):
  - Actual length of one piece of the small item of work
- Quantity of LIP Requirements (ea):
  - Counted off drawings or by calculation.
- Convert Standard Lengths (in):
  - Convert each standard length of lumber to inches.

8’ x 12” = 96”	14’ x 12” = 168”
10’ x 12” = 120”	16’ x 12” = 192”
12’ x 12” = 144”	

STANDARD LUMBER LENGTH CALCULATION (PART 2)

- Number of LIP Pieces (ea): Number of LIP pieces that can be cut from each Standard Length of Lumber.
  - Standard lumber length (in) ÷ LIP Measurement (in) = LIP pieces per standard lumber length. (**Round Down**)

    - ***96” ÷ 21” = 4 Lip Pieces***

- Number of Standard Lengths (ea): How many Standard Lengths required to cut all LIP Pieces.
  - Total LIP Requirements 4 Total LIP Pieces per Standard Lumber Length = Total Standard Lumber Lengths required. (**Round Up**)

    - ***13 ÷ 4 = 4 8’ Lengths of Lumber***

STANDARD LENGTH CALCULATION (PART 3)

- Standard Length to Use (ea) to minimize waste.
  - Standard Lumber Length x Number of LIP Pieces which can be cut from that length = Total Linear feet of Standard Lumber Length.
    - ***8’ x 4 = 32’***
  - Compare each value. The lowest value will identify the Standard Lumber Length with the minimal amount of waste.

STANDARD LUMBER LENGTH CALCULATION EXAMPLE

- 13 pieces of floor bridging, 1’-9” long are needed to stiffen the floor joists.

Converted Standard Length	LIP pcs cut from std lgth	Number of std lgth	Standard lgth to use
8’ x 12” = 96”	96” ÷ 21” = 4	13 ÷ 4 = 4	8’ x 4 = 32’
10’ x 12” = 120”	120” ÷ 21” = 5	13 ÷ 5 = 3	10’ x 3 = 30’
12’ x 12” = 144”	144” ÷ 21” = 6	13 ÷ 6 = 3	12’ x 3 = 36’
14’ x 12” = 168”	168” ÷ 21” = 8	13 ÷ 8 = 2	**14’ x 2 = 28’**
16’ x 12” = 192”	192” ÷ 21” = 9	13 ÷ 9 = 2	16’ x 2 = 32’

Round ↓ Round ↑

BREAK

PRACTICAL APPLICATION

Math Review

- Why would you want to select the lowest value of your LIP calculations off of the standard lumber length?
- What are the three fundamental conversion formulas that are used to estimate material requirements?

MATERIAL TAKEOFF LIST (MTO)

- MTO: Lists all items of work, detailing:
  - Dimensions
  - Quantities of work
  - Units of measure conversions

- Rules for Compiling:
  - Study *all* drawings, notes & specifications.
  - Measure everything as shown.
  - Measure everything you can see.

TIME SAVERS

- Never use long words if short ones will do.
- Use abbreviations.
- Keep all dimensions, figures and notes.
- Always start in the same place on each drawing.
- Highlight / mark-off items, notes and specifications when completed.
- Take advantage of duplication of design.

MTO - PRECEDENCE

- If a work item is different, list it separately on the MTO. The items of work are estimated in a logical sequence using the following order of precedence:
  - 1st – EXCAVATION
  - 2nd – CONCRETE
  - 3rd – MASONRY
  - 4th – LUMBER
  - 5th – FINISH MATERIALS

CONCRETE & MASONRY MTO ESTIMATING SEQUENCE

- **Excavation**: cuyd/cy
  - Calculate amount by using the dimension measurements for the outside face of the footings ≠ dimensions of the outside face of the walls.

- **Concrete:**
  - Ready-Mix cuft/cf
  - Batch Mix cuft/cf
  - Reinforcement Bar ft
  - Wire Mesh sqft/sf
  - Poly Vapor Barrier sqft/sf
  - Expansion Joint Filler ft
  - Base Course cuft/cf

- **Masonry Wall Surface** sqft/sf
  - Vertical Reinforcement ft

LUMBER MTO LIST

- Lumber is taken off the notes drawings and specifications as:
  - Lumber as the number of standard lumber lengths.
  - Plywood & Siding by the square footage to be covered.
  - Finish Trim by the linear foot.

- Two Categories for Lumber MTO:

  - **Rough Carpentry**
    - Floor Framing (lumber & plywood)
    - Wall Framing (lumber & plywood)
    - Roof Framing (lumber & plywood)
    - Wooden Forms (lumber & plywood)
  - **Finish Carpentry**
    - Siding
    - Trim Work

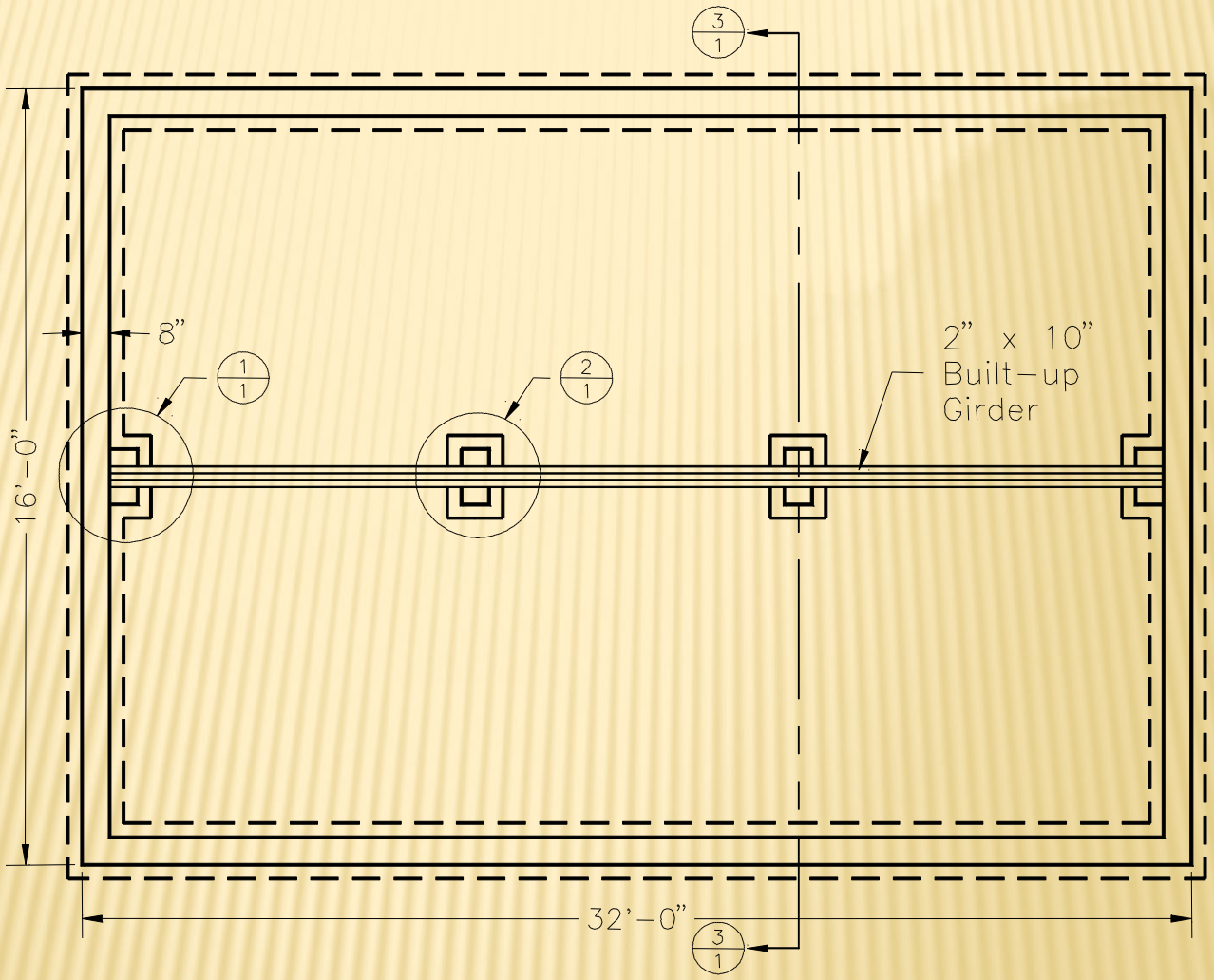
FINISH MATERIAL MTO LIST

- Finish materials are items required to “finish” the exterior and interior of a structure:
  - Doors & Windows ea
  - Shingles sqft/sf
  - Drywall sqft/sf
  - Paint sqft/sf
  - Insulation sqft/sf

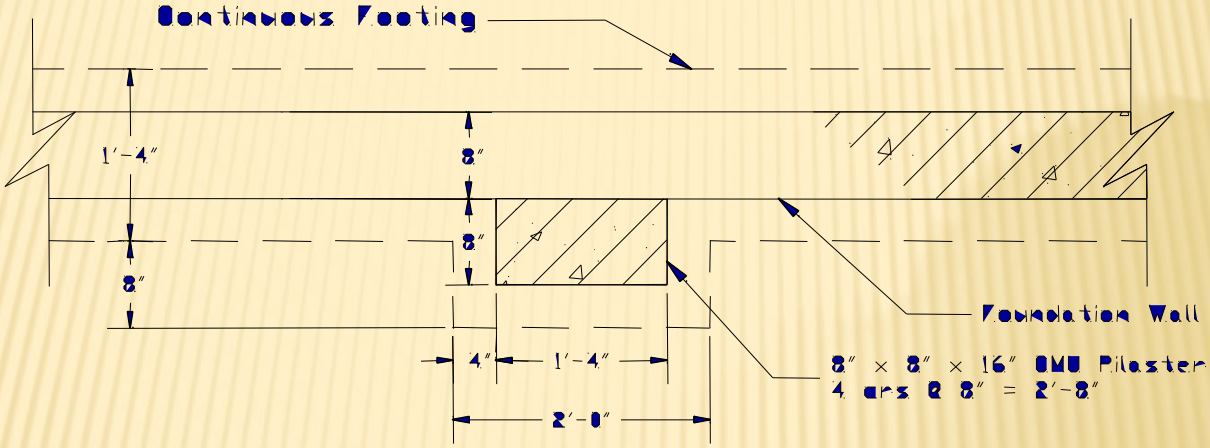
MATERIALS TAKEOFF LIST

DEMONSTRATION

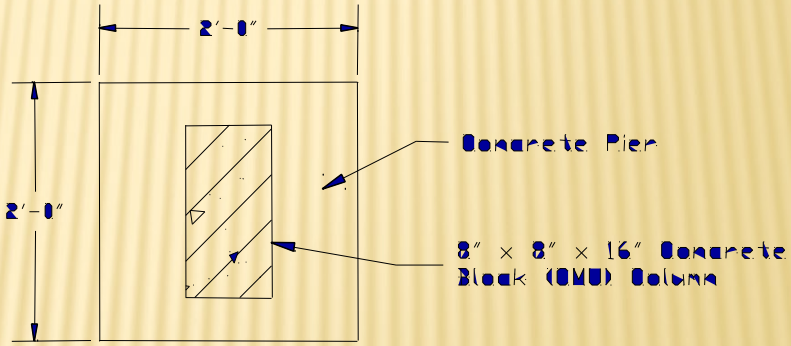
MTO DEMO
FOUNDATION PLAN



MTO DEMO
FOUNDATION DETAILS

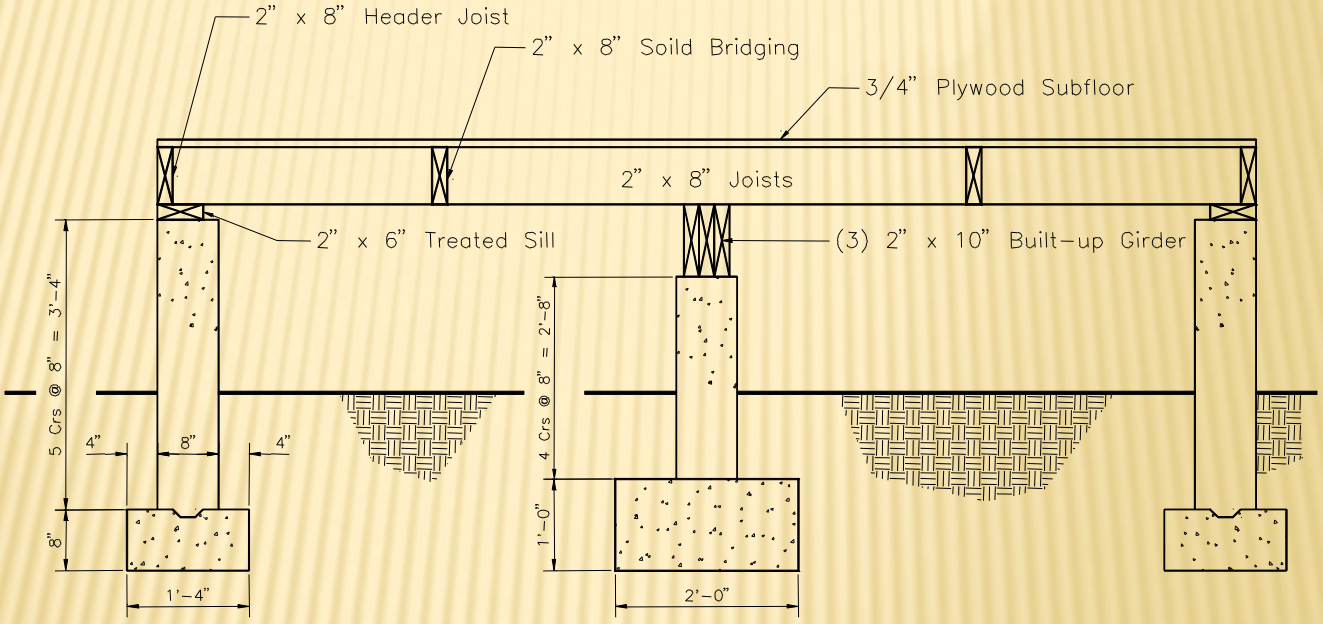


DETAIL 1/1



DETAIL 2/1

MTO DEMO
FOUNDATION & FLOOR SECTION

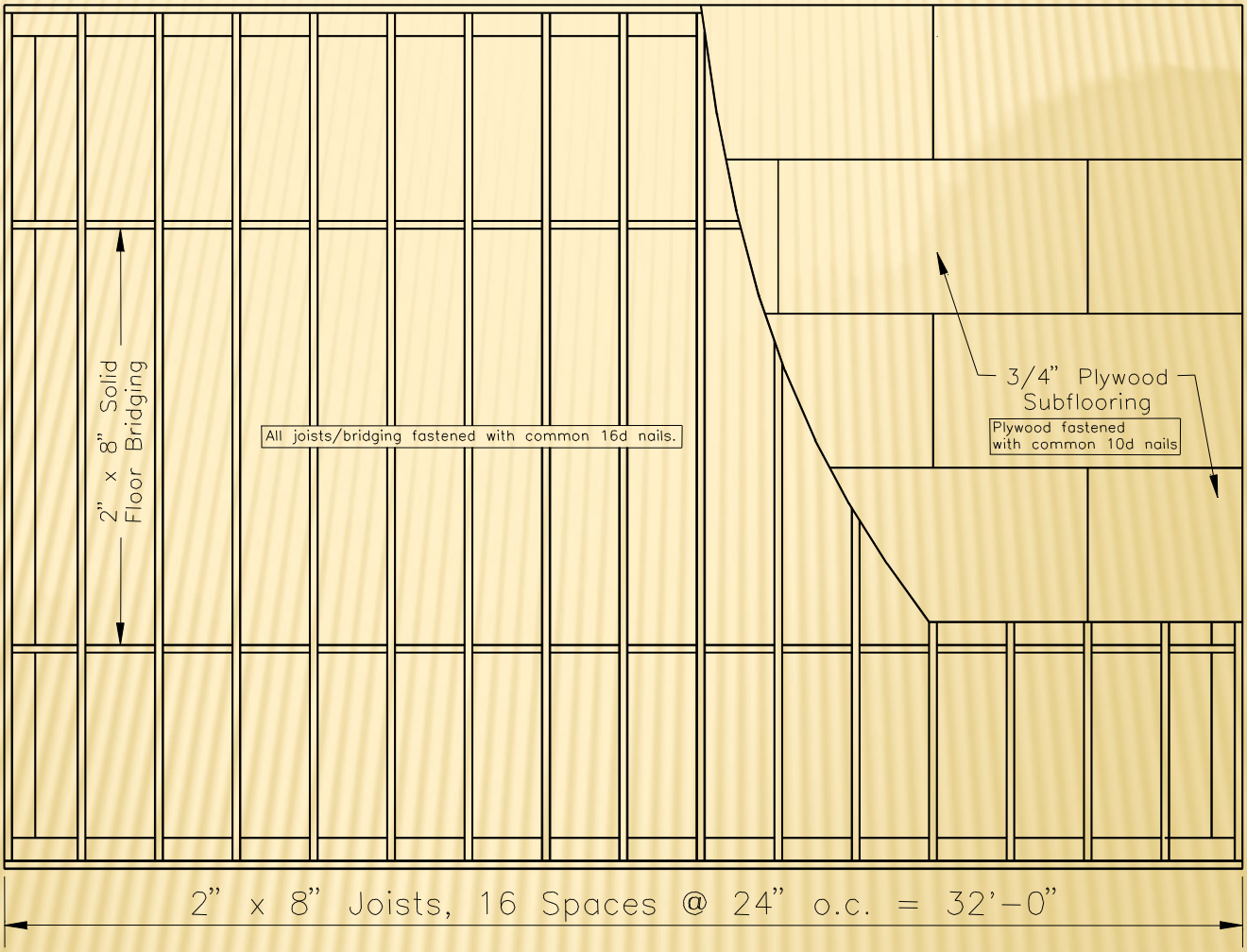


SECTION 3/1

Concrete and Masonry Material Takeoff Sheet

Item of Work	Dimensions	Quantity Required	Concrete Volume (L x W x H)	Masonry Area (L x H)

MTO DEMO
FLOOR FRAMING PLAN



Lumber Material Takeoff Sheet

Descriptive Item of Work	Item U/M	LIP Measure	LIP Qty	STD Lgth to Use	STD Lgth Qty	LIP PCS/ STD Lgth

Bridging Calculation: LIP

Converted Standard Length	LIP pieces cut from std lgth	Number of std lgth	Standard lgth to use	
8' x 12" = 96"				
10' x 12" =				

BREAK

PRACTICAL APPLICATION

Part #1

Material Takeoff Sheets

- What is a materials takeoff sheet used for?
- Where does the information come from to create a MTO?

BREAK

MATERIAL ESTIMATE SHEET (MES)

- MES puts the information on the MTO into detail, showing:
  - Description of work.
  - Detailed description of materials.
  - Units of measure of materials.
  - Quantities of “dissimilar” materials.
  - Quantities of “like” materials.
  - Waste factor allowances.
  - Total material quantities, including waste.

MES (READY-MIX CONCRETE)

- Ready-mix Concrete volumes from the MTO are converted and rounded up to the nearest whole cuyd.
  - The appropriate waste factor is calculated and added, after the concrete volume is converted to cuyds.

MES
(BATCH MIX CONCRETE)

- Batch mix concrete is a proportional mix of:
  - Portland Cement
  - Sand
  - Aggregate (Gravel)
    - Water (not figured into the estimate)
- Standard mix ratio (1:2:3) of:
  - (1) part Portland Cement
  - (2) parts Sand
  - (3) parts Aggregate (Gravel)
    - A 1:2:3 mix concrete will achieve a compressive strength of 2000 psi at 28 days.

BATCH MIX CONCRETE ESTIMATING CALCULATION

- Total concrete volume from MTO x 1.5 (3/2 rule) = Concrete Proportion Ratio (CPR)
  - ***92.98 cy x 1.5 = 139.47***
- Multiply CPR to mix ratio.
  - (1/6 x CPR) + Waste Factor = Total bags of Portland Cement. (Round up)
    - ***1/6 x 139.47 = 23.25 + 5% = 25.0 bg***
  - ((2/6 x CPR) ÷ 27) + Waste Factor = Total cuyds of Sand
    - (Round up to nearest half cubic yard)
    - ***((2/6 x 139.47) ÷ 27 = 1.72 + 10% = 2.0 cy***
  - ((3/6 x CPR) ÷ 27) + Waste Factor = Total cuyds of Aggregate
    - (Round up to the whole cubic yard)
    - ***((3/6 x 139.47) ÷ 27 = 2.58 + 10% = 3.0 cy***

MES
CONCRETE MASONRY UNITS (CMU)

- Nominal Dimensions:
  - 16” x 8” x 8”
- Actual Dimensions
  - 15 5/8” x 7 5/8” x 7 5/8”
    - 3/8” mortar joint between blocks.
- Estimate CMU by Square Feet
- One concrete block = 0.89 sqft of surface area.

CMU ESTIMATING CALCULATION

- Total masonry surface area from MTO (sf) ÷ 0.89 (sf) = Number of CMU blocks (ea)
  - ***325.02 ÷ 0.89 = 365.19***

- Number of CMU + Waste Factor = Total CMU blocks (ea) (Round up to nearest whole block)
  - ***365.19 + 2% = 373.0 blocks***

MES (MORTAR)

- Mortar is a proportional mix of:
  - Portland Cement
  - Masonry Cement
  - Sand
    - Water (not figured into the estimate)
- Standard mix ratio (1:1:6) of:
  - (1) part Portland Cement
  - (1) parts Masonry Cement
  - (6) parts Sand
    - A 1:1:6 mix concrete will achieve a compressive strength of 2000 psi at 28 days.
    - Bonded by a 3/8” mortar joint, bonding 0.054 cuft of block area.

MORTAR ESTIMATING CALCULATIONS

- **Total number of blocks from MTO x 0.054 (cf) = Total amount of mortar to bond all blocks (cf)**
  - ***373 x 0.054 = 20.14***

- **Multiply total mortar requirement to mix ratio.**
  - (1/8 x total mortar) + Waste Factor = Total bags of Portland Cement. (Round up)
    - ***1/8 x 20.14 = 2.52 + 5% = 3.0 bg***
  - (1/8 x total mortar) + Waste Factor = Total bags of Masonry Cement. (Round up)
    - ***1/8 x 20.14 = 2.52 + 5% = 3.0 bg***
  - ((6/8 x total mortar) ÷ 27) + Waste Factor = Total cuyds of Sand (Round up to the nearest half cubic yard)

MES
(BOARDS, LUMBER, TIMBER & PLYWOOD)

- **The unit of measure to estimate boards, lumber, and timber is board feet (bf).**
  - One board foot is equal to a piece of wood having 12 square inches of end area, and is 1 foot long.
- **The unit of measure to estimate plywood is sheet (sh).**
  - One sheet of plywood has 32 square feet of surface area.

BOARDS, LUMBER & TIMBER ESTIMATING CALCULATIONS

- Consolidate and total all “like” wood sizes & grades. Calculate board feet.

- Total all “dissimilar” wood sizes & grades. Calculate board feet.

- Board Feet Calculation
  - ((Thickness (in) x Width (in) x Length (ft) x Quantity) ÷ 12) + Waste Factor = Total Board Feet (Round up)

(2” x 6” x 16’ x 6) ÷ 12 = 96.0 bf + 10% = 106.0 bf

PLYWOOD ESTIMATING CALCULATION

- Consolidate and total all “like” plywood sizes & grades. Calculate sheets required.
- Total all “dissimilar” plywood sizes & grades. Calculate sheets required.
- Sheet Calculation
  - Total Surface area to be covered from MTO ÷ 32 (sf) = Total sheets required + waste factor = Total sheets to order. (Round up)

512 sqft ÷ 32 sqft = 1 6.0 sh + 15% = 19.0 sh

MES (NAILS) & NAIL ESTIMATING CALCULATIONS

- Unit of measure for nails by the pound (lb).

- Three formulas, based on nail size, are used to determine nail requirements.

  - 2d to 12d Nails:
    - ((Nail size x Total bf of lumber to be fastened) ÷ 400) + Waste Factor = Total nails (lbs) (Round up)

(10d x 523 bf) ÷ 400 = 13.08 + 10% =

15.0 lbs

NAIL ESTIMATING CALCULATIONS (CONT)

- 12d to 60d Nails:
  - ((Nail size x Total bf of lumber to be fastened) ÷ 600) + Waste Factor = Total nails (lbs) (Round up)

(763 bf x 16d) ÷ 600 = 20.35 + 10% = 23.0 lbs

- 2d to 12d Nails for plywood:
  - ((32 sqft x Total sheets to be fastened) ÷ 400) + Waste Factor = Total nails (lbs) (Round up)

(32 sf x 19 sh) ÷ 400 = 1.52 + 10% = 2.0 lbs

Material Estimate Sheet

Work Description	Detailed Material Description	Material U/I	Material Quantity	Waste Factor	Total Qty

MATERIALS ESTIMATION SHEET (MES)

DEMONSTRATION

BREAK

PRACTICAL APPLICATION

Part #1 & #2

Material Estimate Sheets

- What is the purpose of a materials estimate sheet?
- What is a “board foot”?

BREAK

BILL OF MATERIALS (BOM)

- Consolidated list of:
  - **All material descriptions**
  - **Quantities**
  - **NSN’s**
  - **Unit of issue**
  - **Unit cost**
  - **Total cost of individual items**
  - **Total cost of all materials required**
- Source document used to order project materials.
- Manufacturers, venders, companies and acceptable replacement items are also listed to prevent poor

BILL OF MATERIALS (BOM)

STANDARD UNITS OF MEASURE				
MATERIAL	**U/M**		**MATERIAL**	**U/M**
CONCRETE (Ready Mix)	cuyd		DIMENSION LUMBER	bf
SAND	1/2 cuyd		TIMBER	bf
GRAVEL	1/2 cuyd		PLYWOOD	sh
CEMENT	bg		TRUSS'S	ea
CONCRETE BLOCK	ea		DRYWALL	sh
REINFORCEMENT BAR	ft		NAILS	lb
WELDED WIRE	ro		SCREWS	bx
CRUSHED ROCK	cuyd		ANCHOR BOLTS	ea
POLY VAPOR BARRIER	ro		BOLTS	ea
FILL DIRT	cuyd		DRYWALL SCREWS	bx
BATT INSULATION	ro		DRYWALL TAPE	ro
PAINT	ga		DRYWALL COMPOUND	ga
HINGES	ea		LAP SIDING	sq
INSECT SCREEN	ro		T-111 SIDING	sh
ROOFING FELT	ro		CORRUGATED ROOFING	sh
ROLL ROOFING	ro		ASPHALT SHINGLES	sq
DOORS	ea		WINDOWS	ea
ELECTRICAL WIRE	ft		ELECTRICAL OUTLETS	ea
ELECTRICAL SWITCHES	ea		LIGHTING	ea
ELECTRICAL CONDUIT	ft		JUNCTION BOXES	ea
SERVICE HEAD	ea		CONDUIT CONNECTORS	ea
PLUMBING FIXTURES	ea		PLUMBING PIPE	ft
PIPE COUPLINGS	ea		FORM TIE WIRE	ft

Bill of Materials

Detailed Nomenclature Description	NSN	U/I	Unit Cost	Qty Req	Total Cost	Source/ Substitute

- What is a bill of materials?
- What is a bill of materials used for?

SUMMARY

- MATHEMATICAL CONVERSIONS
- MATERIAL TAKEOFF LISTS
- MATERIAL ESTIMATION SHEET
- BILL OF MATERIALS